TECHNICAL REPORT
68-29-FL

STUDY OF MILITARY WEIGHT REQUIREMENTS FOR RAW PORK LOINS

Dexter R. Rellis and John L. Secrist

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UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

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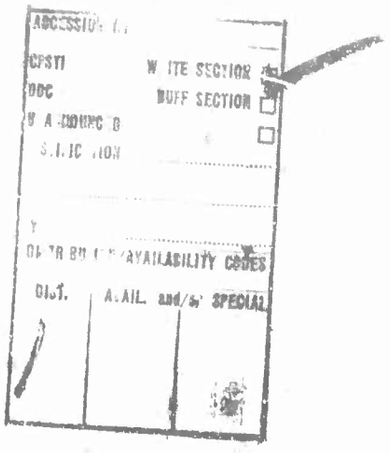

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FOREWORD

Traditionally, pork loins have been commercially priced on a weight basis. The weight-pricing schedule has been based upon four bone-in weight ranges: (1) 12 pounds and under, (2) 12 to 16 pounds, (3) 16 to 20 pounds and (4) 20 pounds and over. This weight grouping had been established as indicative of consumer preference.

Military specifications were written on the basis that the maximum bone-in loin weight which would provide optimum military utility was 18 pounds.

During the past ten years the pork production industry has made significant genetic, nutritional and environmental improvements. These factors, to varying degrees, have advanced those attributes of quality which are sought by today's military consumer, i.e., tenderness, flavor, juiciness and a large ratio of lean meat to fat and bone.

Successful production efforts have contributed to an increase in the upper loin weight within each weight range. The former weight ranges have now been replaced with the following: (1) 14 pounds and under, (2) 14 to 17 pounds, (3) 17 to 20 pounds and (4) 20 pounds and over.

The extension of the present permissible bone-in weight would reflect a monetary savings to military services. It was the absence of knowledge concerning the acceptance of heavier pork loins which initiated this investigation.

FERDINAND P. MEHRLICH, PhD.
Director
Food Laboratory

APPROVED:

DALE H. SIELING, PhD.
Scientific Director

C. T. RIORDAN
Colonel, QMC
Commanding

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\BSTRACT

Pork loins weighing between 12 and 24 lb. were tested for cutting and cooking yield, utility to meet fabrication requirements, and consumer acceptance. Percent yield of ready-to-cook meat was generally higher for lighter loins. Percent fat and lean trim was less for 12- and 14-lb. loins. Bone yield among loin weight groups did not differ significantly except for 12-lb. loins which had the highest percent bone. Weight of loin slices generally increased as loin weight and slice thickness increased. However, encased loins had less weight increase, yielding more uniform slice weight. Range of roast cooking times was 28 to 32 min. per lb., with less cooking time per pound required for the heavier loin roasts. Mean slice cooking time generally increased as loin weight increased. Percent yields of ready-to-eat cooked roasts generally showed an increase in the lighter, bone-in loin weight groups. Percent yields of ready-to-eat cooked slices showed no relationship to bone-in loin weight. No significant differences were found among the roast acceptance scores from the loin weight groups. On the other hand, slices fabricated from the 16-, 18-, and 22-lb. loins were preferred to those from the other loin weight groups. Except for slices from 24-lb. loins, all roasts and slices received a hedonic rating of 6.0 or higher indicating consumer acceptance (based on a hedonic scale of 9 points).

INTRODUCTION

Boneless pork roasts and pork slices have been purchased by the military since 1963 under procurement document MIL-P-35098.

The product requirements stipulate that the pork roasts be trimmed to 1/4 inch or less surface fat, be separated into two halves by a transverse cut, a binding agent (such as pasteurized egg white) applied, and the two halves fitted together lean surface to lean surface and string tied for roasting. The pork slices are cut from the string tied frozen roasts and must meet definitive slice thickness and weight requirements. To date, the commercial loins used to meet military requirements have been restricted to a bone-in weight range of 12 to 18 lb. This practice was based on past experience which indicated that an increase in bone-in weight beyond 18 lb. resulted in finished product which was less palatable. The lower weight restriction was applied to maintain minimum roast weight and slice thickness and weight.

More recently, research findings have been reported which indicate that heavier bone-in loin weights yield an organoleptically acceptable product. Field et al. (1961) found no significant differences in either palatability or tenderness of 160- and 220-lb. hogs, when measured by consumer and panel acceptance tests. The work of Emerson et al. (1964) showed that slaughter weight in the range of 190 to 210 lb. had no significant effect on the palatability and overall acceptability of oven-roasted pork chops. Differences in cooking losses among the chops were also not significant. Carpenter et al. (1963), Kauffman et al. (1964) and Tuomy et al. (1966) reported that with increase in either pork muscle fiber diameter, chronological age or loin weight, there occurred a decrease in panel tenderness scores and an increase in shear force values. However, Tuomy et al. (1966) found these differences in preference within the acceptability range. Varney et al. (1963) and Tuomy et al. (1966) reported that the yield of ready-to-cook meat does not increase with weight of bone-in loins.

Commercially, bone-in loins have been priced according to weight groupings, i.e., 12 to 16 lb.; 16 to 20 lb.; 20 lb. and over. Several contractors have reported that military requirements for pork slice thickness and weight limit the useable bone-in loins to the 16 to 18 lb. weight range. The special selection of the 16 to 20 lb. weight group could create a price disadvantage.

This study was undertaken to investigate the relationship of an expanded bone-in pork loin weight range to cutting and cooking yield, end-product weight and thickness requirements, and overall palatability of pork roasts and slices.

MATERIALS AND METHODS

Forty-eight U. S. No. 1 frozen pork loins were specially selected for weight ranging from 12 to 24 lb. each in 2-lb. increments. Except for the 12- and 14-lb. loin weights, each weight group contained 8 loins. The 12- and 14-lb. loins were not tested for cooking yields or taste panel acceptance evaluation. Past experience has shown these loins to be acceptable for the fabrication of pork roasts and slices. The loins were thawed at 40°F for 24 hr, after which they were weighed, boned, and trimmed to a maximum surface fat thickness of 1/4 inch. Weights of the following portions were recorded: boned, trimmed, ready-to-cook loins; fat trim; lean trim; bone; tenderloin. The loins were cut in half perpendicular to their length and the two halves placed together (ham end with shoulder end) with the back fat surface on the external portion of the loins.

Four of the loins from each weight group were selected at random for slicing and slice measurements. Two of these loins were string tied and the other two encased in Visking fibrous casings. Due to problems in encasing, the 16-lb. loins were string-tied only. The remaining four loins in the 16-, 18-, 20-, 22-, and 24-lb. weight ranges were string-tied for roasting. The loins were double wrapped in a polyethylene film-laminated freezer paper, frozen at -20°F and held at this temperature for approximately 60 days. Upon removal from the freezer, the string-tied loins for roasting were thawed for 24 hours at 40°F. The string-tied and encased loins for slicing were sliced on a band-saw while still hard-frozen. Table I illustrates the breakdown of the loin weight groups into roasts and slices.

Slices were cooked from the frozen state on a surface griddle at 350°F until the pink internal slice color just disappeared. Roasts were cooked from the thawed state in uncovered square-head pans at an oven temperature of 350°F until the internal center roast temperature reached 180°F. The weights of the slices and roasts before and after cooking were recorded. Cooked loin roasts and slices representing the 16-, 18-, 20-, 22-, and 24-lb. weight groups were presented to 30 panelists for acceptance evaluation. A nine-point hedonic scale was used in accordance with the method described by Peryam and Pilgrim (1957). The slice thicknesses were held constant at 1/2 inch for the consumer acceptance tests.

RESULTS AND DISCUSSIONS

Of particular interest to the fabricators of pork loins are the data on the cutting yields of boneless ready-to-cook meat, expressed as percent of bone-in loin weight (Table II). These show no direct relationship to bone-in loin weight. The yields are generally higher for the lighter weight loin groups, while the percent yields of fat and lean trimmings are greater for the heavier weight loin groups. These findings are similar to those reported by Varney et al. (1963) and Tuomy et al. (1966). The 12-lb. loin weight group shows a high percentage of bone, while the remainder of the loin weight groups show no significant differences in the percent of bone yield. The percent of bone-in loin represented by tenderloin is higher in the heavier weight loin groups.

The thickness-weight relationship of slices are shown in Table III. These data indicate that for each raw slice thickness, with certain exceptions, the slice weight tends to increase as loin weights increase. The exceptions are more predominant in encased loins than string-tied loins. The shaping of the loins by the casing operation provides more uniformity in slice diameter not directly related to loin weight, and therefore should provide more uniform control of slice thickness. Within each loin weight group, an increase in slice thickness resulted in an increase in slice weight. Here again, more variation was observed among the string-tied slices than the slices from encased loins. Since the amount of data for encased loin findings is limited, additional work will be required to determine the magnitude of weight variations in slices from encased loins before any definite comparisons can be made.

Current specification requirements restrict the weight of the bone-in loins to a 12- to 18-lb. range, the slice thickness from 4/8 to 7/8 inch, and the slice weight from 4-1/2 to 5-1/2 ounces (0.28 to 0.34 lb.). The data in Table III indicate that lighter and heavier weight loins do not always produce slices which conform to the necessary slice thickness and slice weight limits. Cooking studies (discussed below) indicate a need for retaining the slice thickness and weight limits.

It was observed that when forcing the boneless loins into casings, the original loin length was reduced and occasionally produced fat pockets in the encased loins. Some difficulty was experienced in obtaining uniform slices especially in the lighter loin weight groups.

Cooking yields and times for roasts are shown in Table IV. Cooking times for roasts ranged from 28 to 32 minutes per pound. The least time required per pound of raw roast was found in the heavier loin weight groups. Cooking yields of boneless ready-to-eat roast meat were generally higher in the lighter bone-in loin weight groups. The largest mean yield of cooked ready-to-eat roast meat was 28.38 percent from the 16-lb. bone-in loins, whereas the 20-lb. loins had the least yield of 23.34 percent; a range in cooked meat yield of 5.04 percent. These data substantiate that of Field et al. (1961) who found that the center loin roasts of lighter weight hogs possessed a lower cooking shrinkage than the loin roasts from heavier weight hogs.

There is no significant difference in the cooking times of loin slices from different loin weight groups when the slice thickness is held constant (Table V). However, within each loin weight group a significant difference does occur in loin slice cooking times as slice thickness increases. This observation is supported by the work of Holmes et al. (1965) where they cooked pork chops to an internal temperature of 170°F. The combined increase in loin weight and slice thickness resulted in a significant increase in the mean cooking time of the pork slices. Restricting the slice thickness to 4/8 to 7/8 inches, in accordance with current specification requirements, does help to control the uniformity of cooking times, especially in the lighter weight loin groups.

Cooking yields of boneless, ready-to-eat loin slice meat showed no direct relationship to the bone-in loin weight. The largest mean yield of 31.58 percent was obtained from the 22-lb. loins, while the smallest mean yield of 26.11 percent was obtained from the 24-lb. loins, a range in the mean yield of cooked slices of 5.47 percent. These data are presented in Table V.

In Table VI, roast acceptance scores show no significant differences among the 5 different loin weight groups. Although significant differences were found among the acceptance scores for fabricated slices from different loin weight groups, there was no direct relationship between loin weight and slice acceptance. The slices from the 24-lb. loin weight group received a hedonic score of 5.8 indicating doubtful consumer acceptance of these loins. Additional tests should be made on the acceptance of these heavier loins before they can be considered for military procurement.

This report indicates that bone-in pork loins in excess of 18 pounds are acceptable for the fabrication of boneless pork roasts and

pork slices. The yields of ready-to-cook meat and the cooked ready-to-eat meat are in line with lower loin weights. This is especially true for bone-in loin weights up to and including 22 lb. Cooked meat from bone-in loins of 22 lb. compares organoleptically to that from lower weight loins. The results of this study indicate that the bone-in loin weight for pork roasts and slices can be increased to 22 lb. to take advantage of the current commercial price advantage for military procurement. Additional work is necessary to explore the possibilities of utilizing bone-in pork loins weighing more than 22 lb. Also, more study is required to determine the effects of encasement of different weight loins on the uniformity of pork slice thicknesses and weights.

SUMMARY

The acceptability of pork loins weighing between 12 and 24 lb. was investigated. The percent yield of the ready-to-cook meat was generally higher for the lighter weight loins; however, weights of boneless ready-to-cook loins were directly related to bone-in loin weight. The percent of fat and lean trim was less in the 12- and 14-lb. loins. Except for the 12-lb. loin weight group, which showed a high percentage of bone, the percent bone yield in the loin weight groups did not differ significantly.

With slice thickness held constant, the slice weight generally increased as loin weight increased. This weight increase was not as demonstrable in slices from encased loins where the casing operation tended to produce slices of more uniform weight.

Cooking times for roasts ranged from 28 to 32 minutes per pound, with boneless roasts from the heavier loins requiring less cooking time per pound. The mean cooking time for slices from different loin weight groups, with slice thickness held constant, generally increased with an increase in loin weight.

The percent yields of ready-to-eat cooked roasts generally showed an increase in the lighter, bone-in loin weight group. Percent yields of ready-to-eat cooked slices, on the other hand, showed no direct relationship to bone-in loin weight. The weights of the cooked roast and slice meat increased as the weight of bone-in loins increased.

No significant difference was found among panel acceptance scores for cooked roasts from the various loin weight groups. Acceptance scores among the slices of the loin weight groups were significantly different with slices from 22-, 18- and 16-lb. loins preferred. Except for slices from 24-lb. loins, roasts and slices from each weight group received an acceptable consumer rating.

TABLE I. Number of Experimental Units for Each Weight Group

Loin Weight Group (pounds)	No. of Loins (units)	No. of Roasts (String-tied) (Units)	No. of Slices* (Loins, string-tied) (Slice Units)	(Loins, encased) (Slice Units)
12	4	0	35	15
14	4	0	35	15
16	8	4	35	0[a/]
18	8	4	35	15
20	8	4	35	15
22	8	4	35	15
24	8	4	35	15

a/ No data due to problems in encasing.

* For additional information see Table III.

Table II. Mean Cutting Yields of Pork Loins Expressed as Percent of Mean Bone-in Weight

Item	Loin Weight Group[1] (Pounds)						
	12[2]	14[2]	16	18	20	22	24
	(11.57)	(13.86)	(15.82)	(17.11)	(19.22)	(21.52)	(23.49)
Ready-to-Cook Meat	43.47	58.60	44.17	41.58	40.46	42.25	40.70
Fat Trim	12.38	11.76	15.00	14.33	15.80	13.51	14.43
Lean Trim	7.35	4.69	9.10	9.72	8.82	8.13	8.39
Bone	30.68	25.54	24.02	27.36	27.23	25.42	28.05
Tenderloin	5.48	5.34	7.71	7.04	7.62	8.22	8.22

1/ Mean weight of loins in the respective groups are presented parenthetically

2/ N=8 except for 12 and 14 lb loins where N=4

TABLE III. Raw Slice Thickness and Mean Weight[1/]

Slice Thickness[3/] (in inches)	Type of Fabrication	Loin Weight Group[2/] (pounds) 12 (11.57)	14 (13.86)	16 (15.82)	18 (17.18)	20 (19.28)	22 (21.52)	24 (23.49)
2/8	String tie	0.078	0.126	0.135	0.148	0.137	0.138	0.161
	Casing	—	—	—	—	—	—	—
3/8	String tie	0.144	0.168	0.183	0.207	0.186	0.195	0.218
	Casing	—	—	—	—	—	—	—
4/8	String tie	0.154	0.184	0.218	0.251	0.250	0.252	0.277
	Casing	0.228	0.213	—	0.198	0.253	0.295*	0.293*
5/8	String tie	0.224	0.246	0.265	0.291*	0.330*	0.324*	0.374
	Casing	0.297*	0.274*	—	0.304*	0.313*	0.373	0.363
6/8	String tie	0.328*	0.345*	0.363	0.346	0.428	0.434	0.442
	Casing	0.356	0.323*	—	0.364	0.367	0.432	0.431
7/8	String tie	0.350	0.359	0.363	0.363	0.423	0.464	0.496
	Casing	—	—	—	—	—	—	—
8/8	String tie	0.375	0.380	0.380	0.418	0.469	0.532	0.562
	Casing	—	—	—	—	—	—	—

1/ Weight is expressed as a decimal fraction of a pound. Each value represents an average of 5 slices.

2/ Mean weight of loins in the respective groups are presented parenthetically.

3/ The encasing of all weight groups modified the dimensions sufficiently to eliminate thicknesses which were 2/8, 3/8, 7/8, and 8/8 inch thick.

* This value is within the military limits for weight at this slice thickness.

TABLE IV. Cooking Times and Mean Yields of Roasts Expressed as percent of Mean Bone-in Loin Weight.

Item	Loin Weight Group 1/ (pounds)									
	16 (15.82)		18 (17.18)		20 (19.28)		22 (21.52)		24 (23.49)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Cooking times (min/lb)	5	30	6	32	7	30	8	23	7	28
Mean yield of cooked ready-to-eat meat (%)	1.84	28.38	3.00	26.14	0.92	23.34	0.09	25.37	2.47	23.58

1/ Mean weight of loins in the respective groups are presented parenthetically.

TABLE V. Mean Cooking Times and Yields of Slices Expressed as percent of Mean Bone-in Loin Weight.

Items	Mean Loin Weight Group[1] (pounds)									
Cooking times for the following slice thicknesses.[2]	16 (15.82)		18 (17.13)		20 (19.28)		22 (21.52)		24 (23.49)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
2/8 inch	1	6	1	6	2	6	1	7	2	7
3/8 inch	1	7	1	7	1	8	2	9	2	9
4/8 inch	1	10	2	10	2	10	3	9	3	8
5/8 inch	2	13	2	15	2	12	3	15	4	13
6/8 inch	1	13	1	15	2	15	2	15	3	15
7/8 inch	2	13	3	17	3	19	3	20	4	20
8/8 inch	2	14	2	20	3	21	3	20	4	20
Mean yield of cooked ready-to-eat meat (%)	1.56	27.32	4.35	31.14	3.93	29.76	2.49	31.58	2.37	26.11

[1] Mean weight of loins in the respective groups are presented parenthetically.

[2] Mean cooking time for 5 slices.

TABLE VI. Mean Acceptance Scores of Cooked Roasts and Slices

Item	Loin Weight Group[1] (pounds)				
	16 (15.82)	18 (17.18)	20 (19.28)	22 (21.52)	24 (23.49)
Roasts	6.9	7.0	6.7	7.2	6.9
Slices (4/8 inch thick)	6.6	6.6	6.0	6.9	5.8

[1] Mean weight of loins in the respective groups are presented parenthetically.

Means underscored by a solid line are not significantly ($p > .05$) different.

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13. ABSTRACT

Pork loins weighing between 12 and 24 lb. were tested for cutting and cooking yield, utility to meet fabrication requirements, and consumer acceptance. Percent yield of ready-to-cook meat was generally higher for lighter loins. Percent fat and lean trim was less for 12- and 14-lb. loins. Bone yield among loin weight groups did not differ significantly except for 12-lb. loins which had the highest percent bone. Weight of loin slices generally increased as loin weight and slice thickness increased. However, encased loins had less weight increase, yielding more uniform slice weight. Range of roast cooking times was 28 to 32 min. per lb., with less cooking time per pound required for the heavier loin roasts. Mean slice cooking time generally increased as loin weight increased. Percent yields of ready-to-eat cooked roasts generally showed an increase in the lighter, bone-in loin weight groups. Percent yields of ready-to-eat cooked slices showed no relationship to bone-in loin weight. No significant differences were found among the roast acceptance scores from the loin weight groups. On the other hand, slices fabricated from the 16-, 18-, and 22-lb. loins were preferred to those from the other loin weight groups. Except for slices from 24-lb. loins, all roasts and slices received a hedonic rating of 6.0 or higher indicating consumer acceptance (based on a hedonic scale of 9 points).

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Pork	9					
Pork loin roasts	9					
Pork loin slices	7					
Cooking	7					
Yield	7					
Fabrication	7					
Specifications	7					
Cutting	7					
Trimming	7					
Acceptability	7					
Quality control	4					
Military rations	4					